4.0 X-37 Assurance Process Profiles

This section defines and describes the baseline of assurance processes currently established for the X-37 program to support mission safety and success. The delineation and specification of this assurance process benchmark is the first important step in the "define - verify - certify" approach described in section 1.4. It is principally through the successful completion of this process that OSMA can effectively support the program/project CoFR/FRR processes and provide informed decisions regarding third-party indemnification requests.

The assurance process benchmark, described in this section is based on the PBMA model described in section 1.6 of the report. It has been tailored to reflect the unique aspects and organization of the X-37 project. These tailored mission assurance processes are listed below:

- 4.1 Management Assurance Processes
  - 4.1.1 NASA Program Management
  - 4.1.2 Boeing Program Management
- 4.2 Systems Engineering Processes
  - 4.2.1 Risk Management
  - 4.2.2 Configuration Management
  - 4.2.3 Technical Reviews
  - 4.2.4 System Safety
- 4.3 Quality Assurance Processes
- 4.4 Hardware Design and Verification Assurance Processes
- 4.5 Software Design and Verification Assurance Processes
- 4.6 Manufacturing Verification and Test Assurance Processes
- 4.7 Pre-Flight Integrated Verification and Test Assurance Processes
- 4.8 Operations Assurance Processes

4.1 Management Assurance Processes

4.1.1 NASA Program Management

The principle program/project management assurance functions specified in NPD 7120.4B, "Program/Project Management," and NPG 7120.5A, "NASA Program and Project Management Processes and Requirements," apply to the management of the X-37 project, the X-37 project plan, and Cooperative Agreement NCC8-190. The major tailoring relates to establishing Boeing as an industry partner as opposed to the traditional government - contractor relationship. With Boeing as the lead partner, NASA has less direct control over the implementation of the agreement than with a traditional contract. However, strong control can be exercised by withholding payments until the NASA project office is satisfied with the Boeing products and progress.

The MSFC X-37 Project Office is relatively small which is consistent with the cooperative agreement procurement approach. In this approach NASA provides support to the industry partner while maintaining independent insight into the project. As an example of NASA insight, NASA must approve all top-level (Level 1A) changes to the cooperative agreement. Level definitions and corresponding NASA approval criteria are summarized in table 4.2. NASA and Boeing jointly conduct periodic change control boards with NASA as the co-chair of the board. In addition, NASA participates in material review boards (MRB's).

MSFC X-37 Project Office insight into the performance and programmatic issues occurs through several functions and insight mechanisms. These functions and mechanisms, listed in Table 4.1, provide timely decision data to help assure mission success.

Table 4.1 X-37 Project Office Insight System (Part-1)

Function	Insight Mechanism	Management Location	Product
MRB	Post review of all closed MRB actions	Resident Office at Boeing	Review Log/Project Office Notification of Problems
Problem Reporting & IFA's	PRACA	Resident Offices at Boeing & MSFC	Problem Report Log/Board Disposition
Alerts	GIDEP & MSFC	MSFC	QS20 File for Review
FRR - DFRC - X-37 Atmospheric - X-37 Orbital	 - Per DFRC Handbook - Per RAM - Per RAM	 - DFRC - MSFC - MSFC	 FRR Package Sign-Off

Table 4.1 (cont.) X-37 Project Office Insight System (Part-2)			
Function	**Insight System**	**Management Location**	**Product**
Indemnification	Under Investigation	NA	NA
Surveillance	Onsite Presence	Resident Office at Boeing	Weekly Notes/Project Office Notification of Problems
NEQA	As Required	Resident Office at Boeing	By-Product of Working Group Actions
NSRS	Current System	MSFC	NSRS Finding (report)
FMEA-CIL	Reliability Analysis	MSFC	FMEA-CIL Report
Hazards	System Safety Report	Resident Office at Boeing & MSFC	Date Package
Certification/ Verification	System Specification	Resident Office at Boeing & MSFC	Certificate of Conformance
Waivers	MSFC Approves All Waivers Prior to Flight	MSFC	Approval by FRR

X-37 Project Risk Management

A principal mission assurance function is that of overall risk management of the project. The X-37 project manager is assisted in performing the risk management function and duties by a support team drawn from within the Space Transportation and Engineering Directorates and the SMA Office at MSFC. The principal objective and focus of this team is to ensure mission success for all X-37 activities throughout all phases of the project via the following penetration level risk management strategy:

- Utilize a standard risk management approach (identify, analyze, track, mitigate, control) and assign penetration levels based on the level of risk in each critical project area
- Deploy workforce consistent with assigned risk
- Adjust penetration levels as risk areas/severity change over the project life cycle
- Penetrate to a level to assure that the industry partner, Boeing, is doing "the right things the right way"

Refer to Section 3.2 for a description of the penetration levels and specific examples of how MSFC Engineering and Space Transportation Directorate resources are currently assigned to address the most critical or highest risk areas identified for the X-37 project.

The MSFC X-37 team also supports the project manager in the development of the X-37 Risk Management Plan which identifies and focuses on the NASA "unique" risks. This plan provides the methodology and approach for the project manager/risk manager to determine if the particular risk is unique to NASA or should be passed on to Boeing for inclusion in their risk management plan. If a risk is designated as unique to NASA, it is assigned to an appropriate task manager, documented on a risk form, and added to the risk database. These risks and associated mitigation strategies are tracked and updated monthly. A risk is designated as unique to NASA if it can be assigned to or is related to one of the following categories:

- Top-level technical performance/safety issue
- Project schedule
- Funding availability
- Contractor/industry partner performance

The following figures represent examples of the risk information sheet that the X-37 project office uses to track the high-level risks that are unique to NASA.

X-37 Project Risk Information Sheet		
Originator: E. Semmes	**Date: 1-18-01**	**Risk #: S1**

Likelihood: **5**	**Risk Statement: (condition; consequence)** Airframe Manufacturing Proceeding w/inadequate design maturity.
Consequence: **3**	
Timeframe: **Current**	

Context:
The X-37 has proceeded with airframe manufacturing absent of a rigorous requirements review and a traditional critical milestone review. Fundamental requirements documents remain at large and requirements flowdown has not been shown. Additionally, drawings and datasets are incomplete with ongoing impacts (e.g., load changes, fastener details) resulting in revisions and cancellations.

Approach: Research / Accept / Watch / Mitigate
A combination of approaches is being used including our acceptance of the programmatic consequences (cost, schedule) of proceeding with manufacturing without a mature design which has been thoroughly reviewed and subjected to traditional critical milestone reviews. We are monitoring the effects to manufacturing through weekly Airframe/Structures IPT telecons and will mitigate future manufacturing plans by conducting a CDR.

Contingency Plan and Trigger:
Contingency plans are based on severity of consequences and include repair, augmentation, redesign, and/or remanufacture.

Status:		Status Date:
Lower Fuselage Repair – Including spring-in, core crush, ramp repair, and hole repair: Lower Fuselage repair is in its final stages w/core crush cure expected to begin on 2/13/01. Spring-in and ramp repair reportedly have produced good results. Upon completion of core crush autoclave curing, the fuselage will undergo NDT. We expect laser tracking and/or other methods to provide better insight into manufacturing tolerance results in early March.		
Lessons Learned: Ensure formulation rigor and implementation discipline through conduct of adequate reviews and gates at critical milestones.		
Approval	**Closing Date**	**Closing Rationale**

X-37 Project Risk Information Sheet		
Originator: Stewart	**Date: 11/29/00**	**Risk #: Ops-4**

Likelihood: 1	**Risk Statement: (condition; consequence)**
Consequence: 5	**Shuttle flight for X-37 is not approved; possible delay in working Shuttle integration activities such as timeline development**
Timeframe: **Mid**	

Context:
Current plan is to have 2 Shuttle flights with the X-37 vehicle. Currently we are not on an approved manifested flight. Depending on the timeframe of this flight, integration activities might be impacted

Approach: Research / Accept / Watch / Mitigate
Watch

Contingency Plan and Trigger:
ELV launch

Status: **Status Date: 11/29/00**
- Preliminary manifested on STS-120 in May of 2003

Lessons Learned:

Approval	Closing Date	Closing Rationale

Certification of Flight Readiness (CoFR) and Flight Readiness Review (FRR)

An additional responsibility and function of the NASA X-37 project office/project manager is to develop a comprehensive CoFR/FRR process which addresses the specific and unique needs of the project. This process is currently under development and is being tailored from a generic CoFR/FRR process.

4.1.2 Boeing Program Management

Integrated Management Structure

The integrated management structure for the X-37 project represents a tailored version of the overall integrated product/process development (IPPD) management approach Boeing has deployed on all programs in recent years.

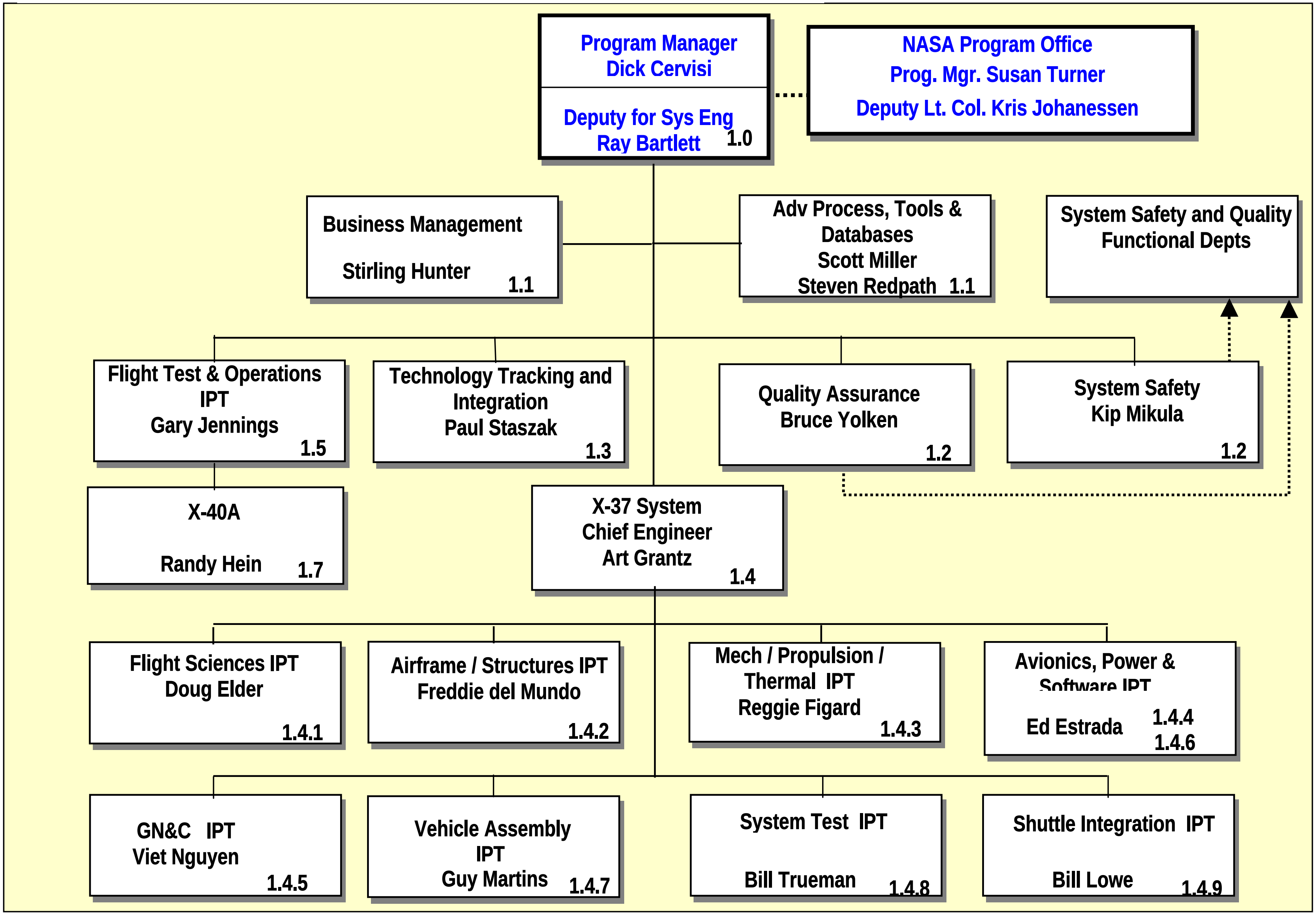
The principal features or attributes of the IPPD management approach include:
1) aligning the organizational structure with the work breakdown structure (WBS) to increase product-focused accountability and clearly define responsibility; 2) blending functions into a seamless organization to eliminate barriers and enhance producibility and supportability during the design process; 3) defining product ownership in a multidiscipline team to foster communication and coordination and facilitate exchange of ideas; 4) integrating lead and support contractors into full participation in the integrated product teams (IPT's); and, 5) assuring full customer participation and insight to improve quality of the final product.

Thus, the X-37 program team is product-focused and consists of a number of multidiscipline IPT's. These IPT's are centered on identifiable products with complete responsibility, accountability, authority, and the requisite resources (budgets, skills, knowledge, tools, and integrated information systems). Full partnership with the customer and suppliers is achieved, as they are working members of the IPT's.

Organization and Responsibilities

As mentioned above, the Boeing X-37 program organization (figure 4.1*)* is keyed to the program work breakdown structure (WBS). The program manager has selected support staff and integrated product team leaders empowered with the appropriate responsibility, accountability, and authority for execution of their assigned WBS elements. Government and major subcontractors are integrated into the IPT, as appropriate, to their functional involvement in the program.

Figure 4.1 Boeing X-37 Project Organization



X-37 Program Operation Guidelines Document

The overall management process for the X-37 program is defined by the program operations guideline (POG) document. The POG provides direction for the implementation and establishment of processes and procedures to permit the expeditious design, development, production, checkout, and test of the X-37 system. These guidelines also provide documentation that will satisfy both Boeing and NASA management that the design intent has been accomplished and verified.

Program Management for Rapid Prototyping

As noted above, the program management philosophy implemented in response to the POG is centered on the IPPD approach which facilitates timely decisions, promotes effective communication, and provides direct customer insight throughout all program phases. To accomplish their responsibilities and duties, the X-37 program manager and his or her staff will, as a minimum, employ the following best practices to ensure contract compliance, customer satisfaction, timely decision-making, and sound technical, financial, and schedule performance:

- Detail program planning/program execution and integrated schedules
- Earned-value/payment milestone system
- Closed-loop corrective action
- Management information system visibility
- Risk management
- Configuration management
- Technical performance measurement (TPM)
- Customer communication plan
- Supplier management system
- Use of independent review
- Help-needed system executive management support

A number of the above areas will be described in detail in later sections of this report.

Each of the above best practices will be oriented specifically to the rapid prototyping needs of the X-37 program, the customer, and Boeing management in order to enhance successful program execution. Additionally, the X-37 program will take maximum advantage of breakthrough processes used on other Boeing programs. To ensure the success of these improvements in cost, schedule, and quality, Boeing embraces the following program philosophies:

- One hundred percent electronic solid model design
- Use of digital pre-assembly, assembly simulations, and electronic work instructions
- Full configuration management of all electronic design/build data
- Digital model as sole authority
- IPT's will release electronic build-to packages that have part number controlled relationships

- Program provides a controlled single source of product data
- Computing tools follow open-standard architecture principles

Boeing program management will evaluate exceptions to the best practices indicated above on a case-by-case basis.

4.2 Systems Engineering Processes

Boeing, as the lead partner, has the overall responsibility for X-37 project systems engineering and integration. To this end, the following sections describe major system engineering and integration assurance functions.

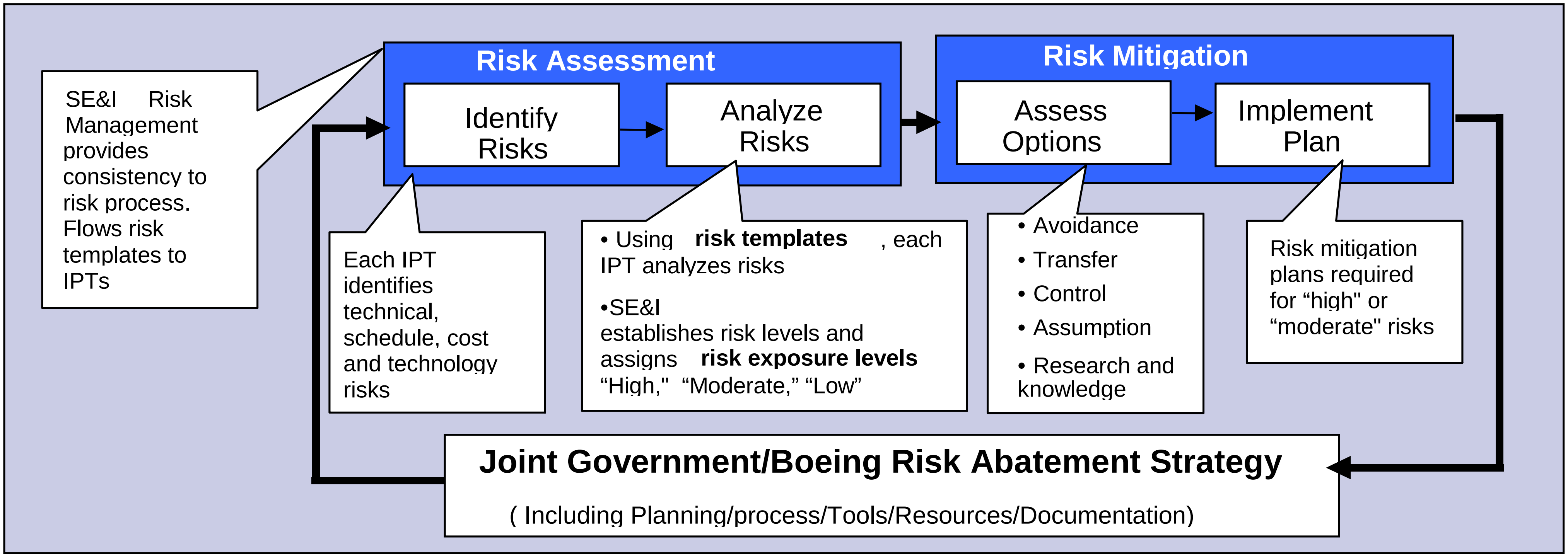
4.2.1 Risk Management

The X-37 risk mitigation management process derives from the Boeing best practices developed from past programs and employed in current programs. The process has been tailored to meet the requirements of the X-37 program while operating in the rapid prototyping mode.

The risk mitigation plans developed by each IPT and reviewed weekly by the program manager are key to the risk mitigation process.

Responsibility for implementation of the risk mitigation plans resides with the IPT's. Figure 4.2 depicts the elements of the program risk process. Each IPT and its team members have responsibility for identifying risks within their own IPT. Once a risk has been identified, a risk analysis is performed to assess: 1) the likelihood that the risk will occur, and 2) the severity of consequences to the program should the risk occur. The risk analysis is conducted by a team which includes the risk manager, the IPT leads, and other personnel as required.

Figure 4.2 Elements of the Program Risk Process



For each defined program risk, the assessed likelihood and severity values are plotted on a risk map to determine the overall program risk level. A color code is used to denote the risk level, (e.g., low-green, moderate-yellow, high-red). Figure 4.3 is an example of a program risk map.

The main goal of the risk mitigation process is to move all defined risks to the lowest (green) level. There are five basic risk mitigation options: 1) avoidance, 2) transfer, 3) control, 4) assumption, and 5) research and knowledge. The IPT assigned to a risk is responsible for preparing a mitigation plan. The plan must define the options for mitigation, the selected approach, and recovery options in the event the basic plan falls short of predictions. The Systems Engineering and Integration (SE&I) IPT updates the risk list and reviews the status of IPT risk mitigation planning on a weekly basis. Authority to adopt all resolution plans lies with program management.

4.2.2 Configuration Management (CM)

The Boeing CM approach is designed to provide support to all areas of the X-37 project. The X-37 CM lead, as a member of the SE&I IPT, is responsible for planning, establishing, and implementing the CM systems, procedures, and controls across all elements and levels of the program. These include:

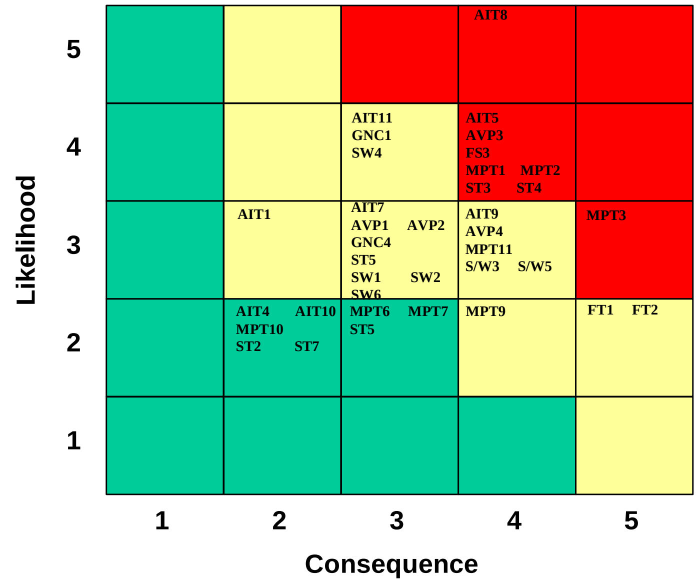
- Program Management
- Integrated Product Teams
- Subcontractors
- Airframe Manufacturing (St. Louis, Mo.)
- Assembly, Integration, and Test (AIT) (Palmdale, Ca.)

The principal CM operating documents employed by Boeing for the X-37 project are:

- Program Operating Guide (POG)
- CM Plan - PP877-0002A
- EIA-649 - National Consensus for Configuration Management
- MIL-STD-973
- ISO 9000 Series
- Boeing internal procedures
    - Specification requirements
- Deviation/waivers

-
-

Likelihood
5 Near Certainty
4 High Likelihood
3 Possible
2 Low Likelihood
1 Not Likely



Conseq	Technical	Schedule	Cost	Program
5	No alternatives	No alternatives	No alternatives	Cancellation
4	A few very difficult alternatives	Major program milestone delays	>40% Cost Growth	Unable to satisfy many program objectives
3	Alternatives very complex	Significant schedule delays	>20% Cost Growth	Requires program restructure
2	Alternatives more difficult	Some schedule slippage	<20% Cost Growth	May require program restructure
1	Alternatives equal to baseline	Alternatives within schedule	Alternatives within cost	No impact to program objectives

Figure 4.3 Program Risk Map

The overall CM change control process as applied to the X-37 project incorporates four levels of control and the associated NASA approval criteria (see table 4.2).

Level Definition	NASA Approval Criteria	
• **Level 1A Definition - changes that affect the contract/agreements including any additions, deletions, or modifications to task agreements with government centers.**	**NASA agreement and signature required. (Boeing may proceed at their own risk pending NASA approval or disapproval)**	**Special Boards**
• **Level 1 Definition - changes that significantly impact total program cost, schedule, or objectives.** • **cost ≥ $500 K** • **schedule ≥ any schedule increase to critical program milestones** • **objectives ≥ any change from SRR**	**NASA signature required; agree or disagree recorded. Boeing may proceed without NASA approval within the contract/agreement.**	
• **Level 2 Definition - changes that fall below the criteria for Level 1, but impact total vehicle performance, interfaces, or multiple IPTs.**	**Participation welcome, but approval not required.**	**Technical Interchange Meetings**
• **Level 3 Definition - changes that affect subsystem performance only, and do not affect vehicle performance or IPT interfaces**	**None**	**IPT Meetings**

Table 4.2 Approval Criteria

A principle distinction between Level 1A and Level 1 is that Level 1A encompasses changes in scope of work whereas Level 1 represents within scope changes.

Accomplishing the traditional configuration management functions of authorizing, archiving, and distributing within the dynamic trade study environment of the one-of-a-kind X-37 project presents a significant challenge. This requires the application of CM in the traditional area of document control and the development and implementation of CM techniques for the control of electronic engineering databases.

As regards the change control of documents, the CM lead has the responsibility for formal release of hardware and software including:

- Specifications
- Statements of Work
- Test Plans, Procedures, Reports
- Program Milestone Documents

Specific assignments include the issuing of document numbers, master change record (MCR) numbers, reviewing all documents, maintaining hard copy files, and maintaining document and MCR status logs on the Enterprise Visibility System (EVS). The CM lead also has responsibility for maintaining the status of deviations, waivers, and engineering change proposals (ECP's).

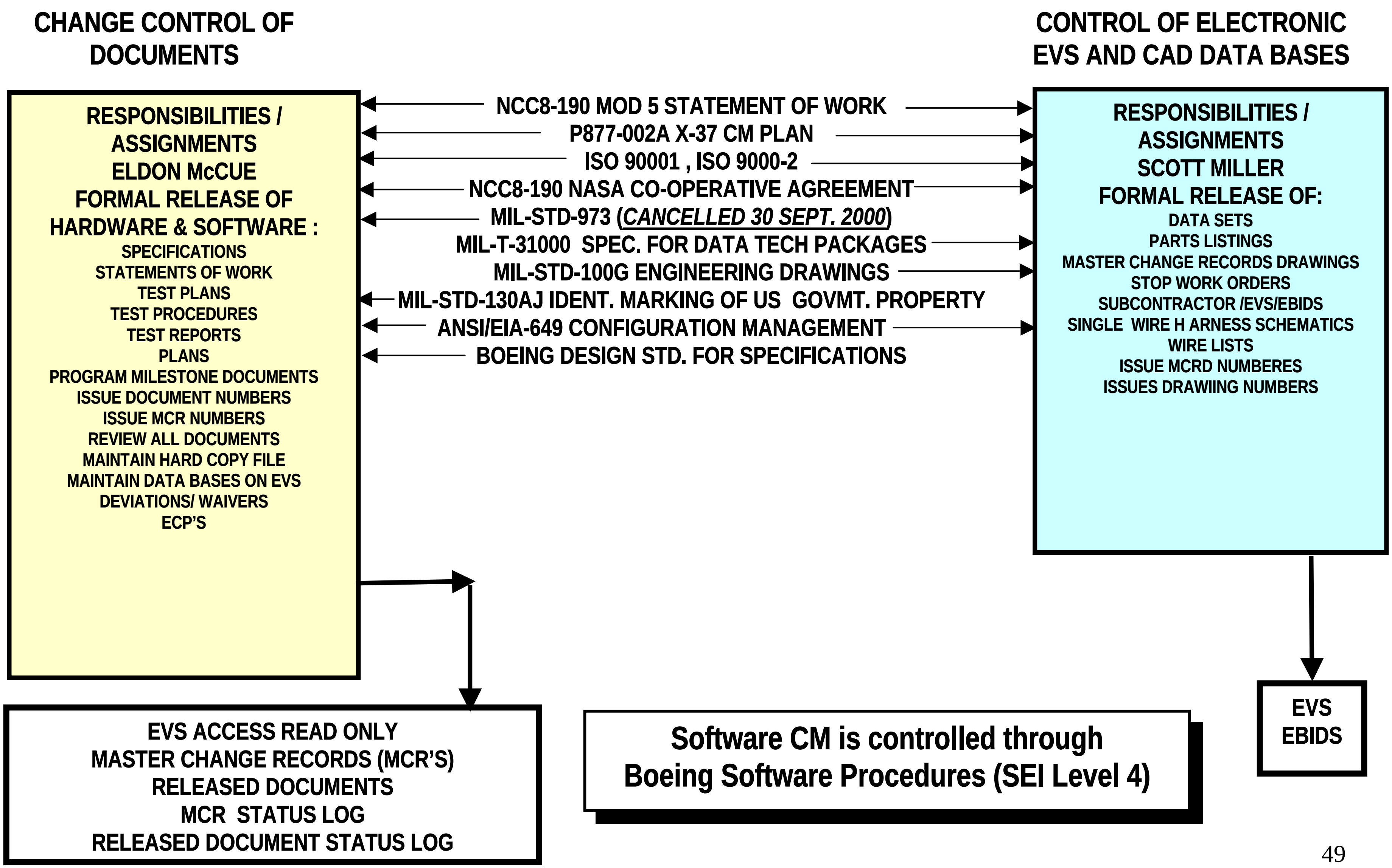
The CM lead is supported and assisted by an individual who has the responsibility for control of the electronic EVS and computer aided design (CAD) databases. These responsibilities include the formal release of:

- Data Sets
- Parts Listings
- Master Change Records Drawings (MCRD) drawing numbers
- Stop Work Orders
- Subcontractor/EVS
- Single Wire Harness Schematics and Wire Lists

Overall CM and change control process responsibilities are depicted in figure 4.4.

Figure 4.4 Configuration Management Responsibilities

Configuration Management Responsibilities



Change control management at the top levels (i.e. Levels 1A and 1) address the definition of top-level system requirements and the flow down of those requirements into lower level subsystem and parts level specifications.

4.2.3 System Safety Process

The top-level system safety process for the X-37 project is based upon a traditional approach of identification, assessment, and mitigation of all potential system safety hazards and risks. In particular, the mitigation approach follows a standard hazard reduction hierarchy where precedence is given to "designing out" hazards followed by providing safety devices, warning devices, or special procedures (see figure 4.5).

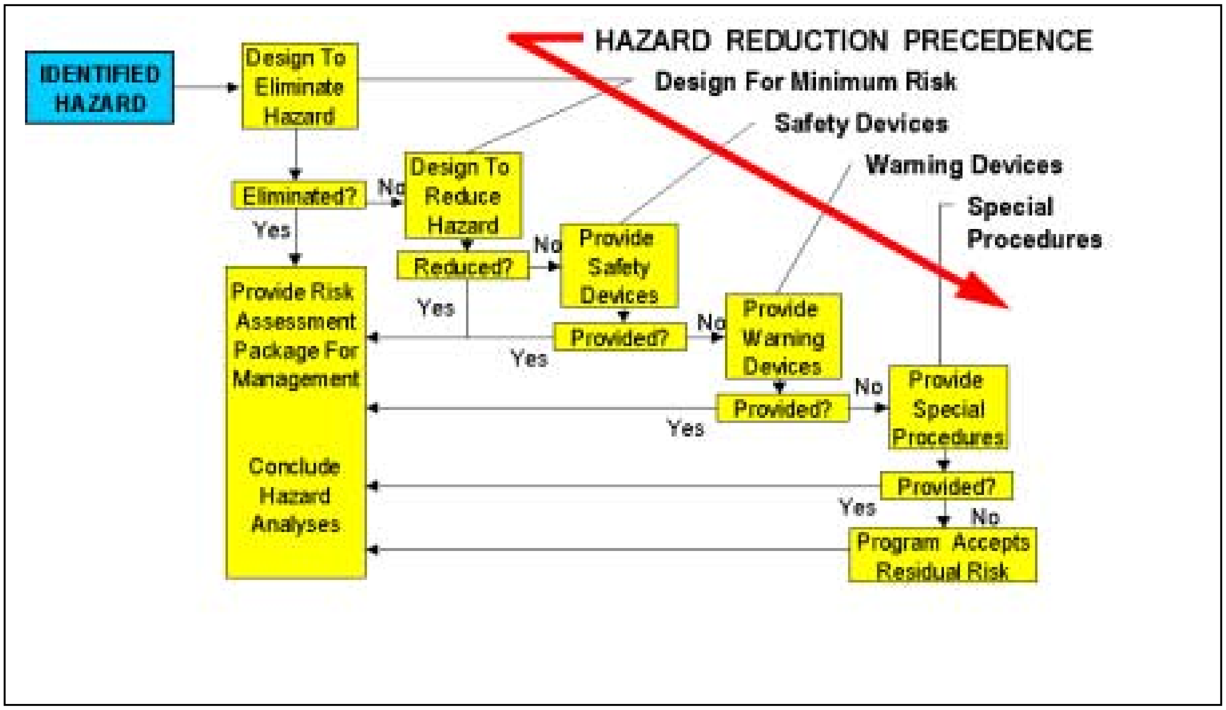


Figure 4.5 Hazard Reduction Procedure

The totality of the system safety process is documented to ensure appropriate participation and communication across all levels of the project. This is accomplished through a number of critical communications interfaces:

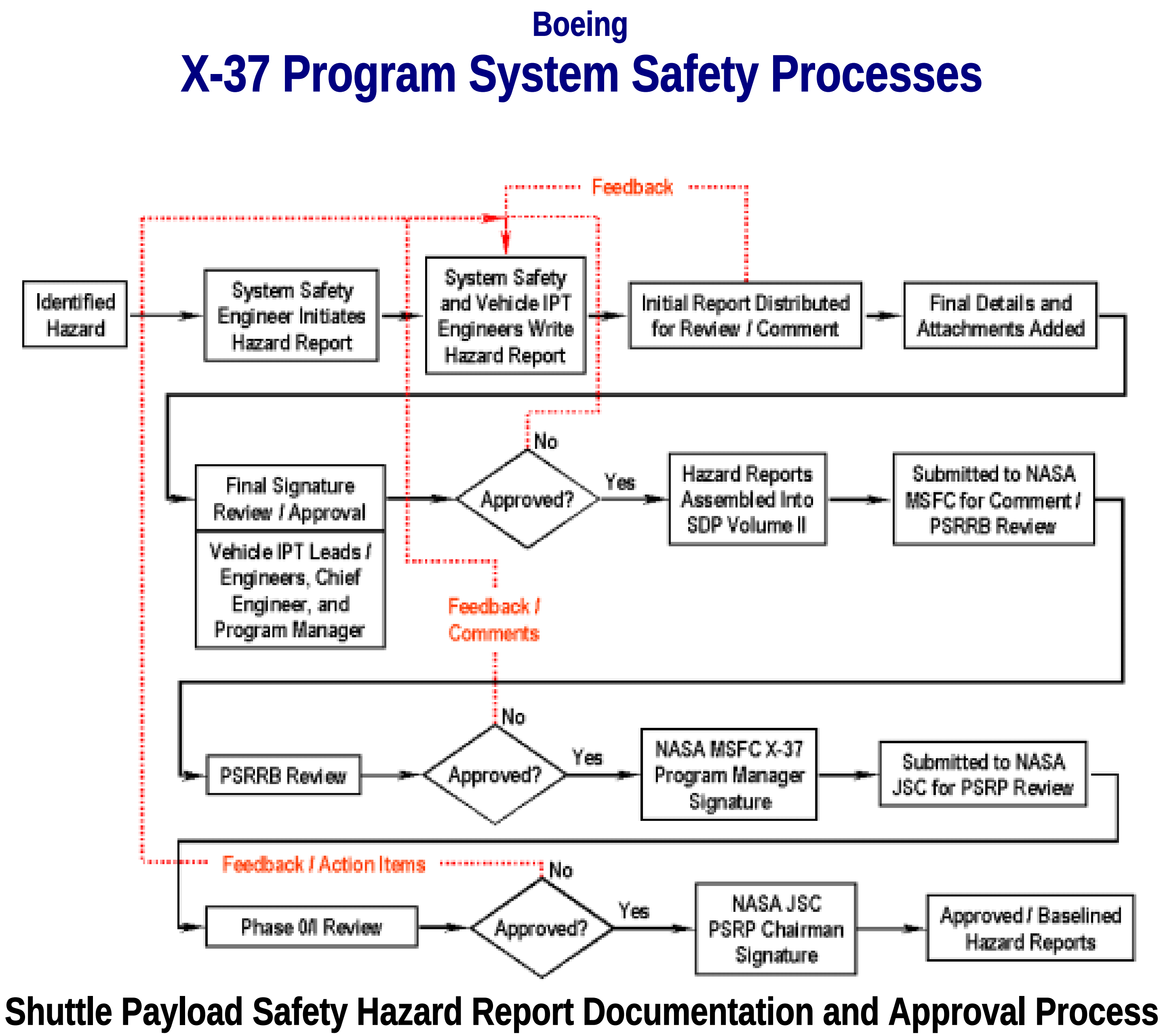
- Safety Watch List (Boeing internal)
- Direct personal interface/interaction with Boeing Seal Beach X-37 vehicle IPT design engineers
- Direct personal interface/interaction with MSFC SMA lead
- Interface/interaction through technical interchange meetings (TIM) with NASA
- KSC/JSC/DFRC/LaRC, USAF AFFTC/30th Space Wing/45th Space Wing, Boeing Huntsville System Safety

- PSRP Reviews
- GSRP Reviews
- SSWG Meetings

Hazard Report Process and Scope

As a potential Shuttle payload, the X-37 is subject to the Shuttle Payload Safety Review Panel (PSRP) process (see figure 4.6).

Figure 4.6 System Safety Process



Consequently, the project is also developing and implementing an internal hazard report documentation, review, and approval process patterned on the known and proven Shuttle process. This process is described in figure 4.7.

The intended scope of the hazard reporting process addresses all potential phases of X-37 vehicle operation from manufacturing through post-flight recovery as depicted in figure 4.8.

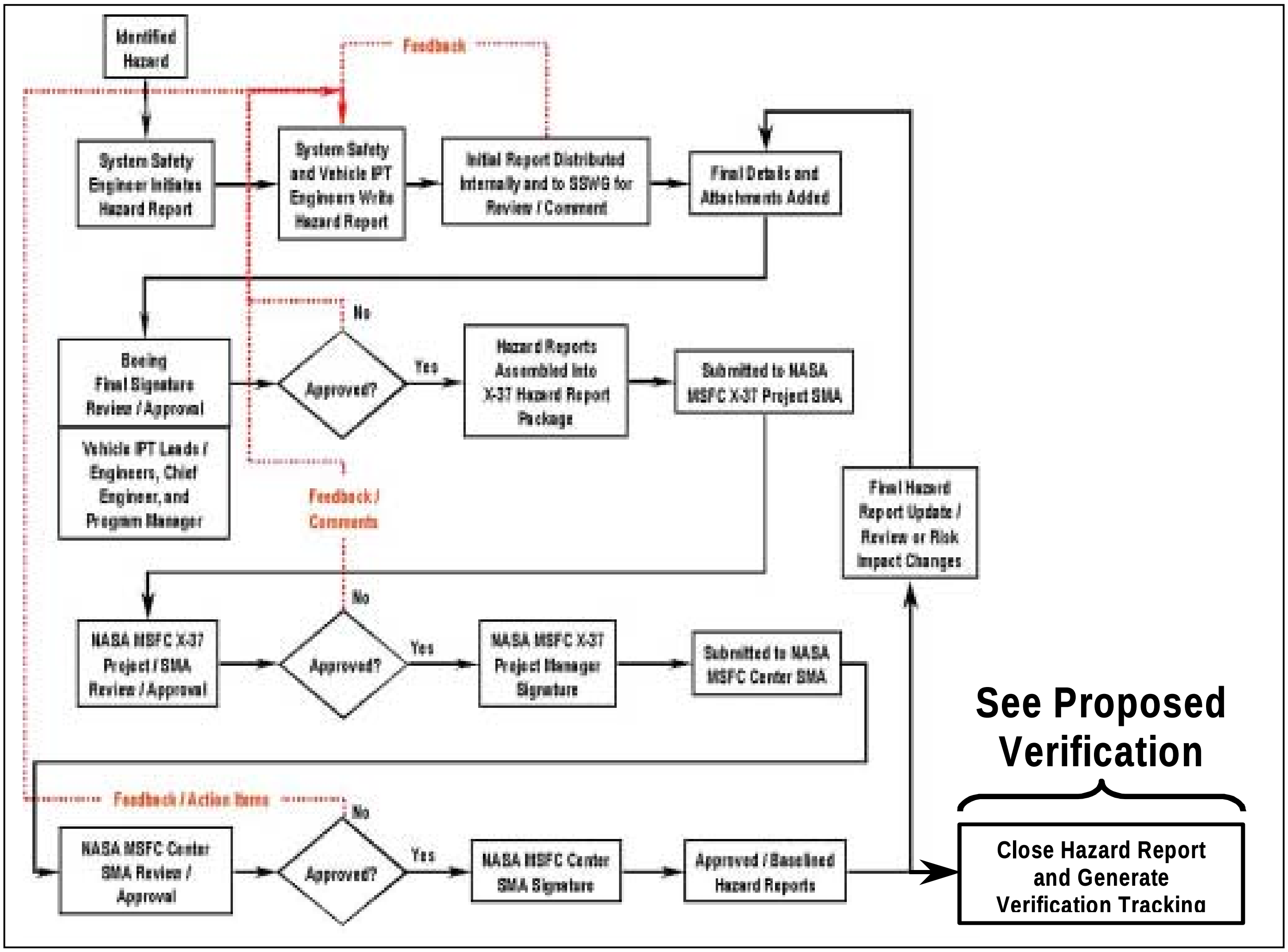


Figure 4.7 Hazard Reporting and Approval Process

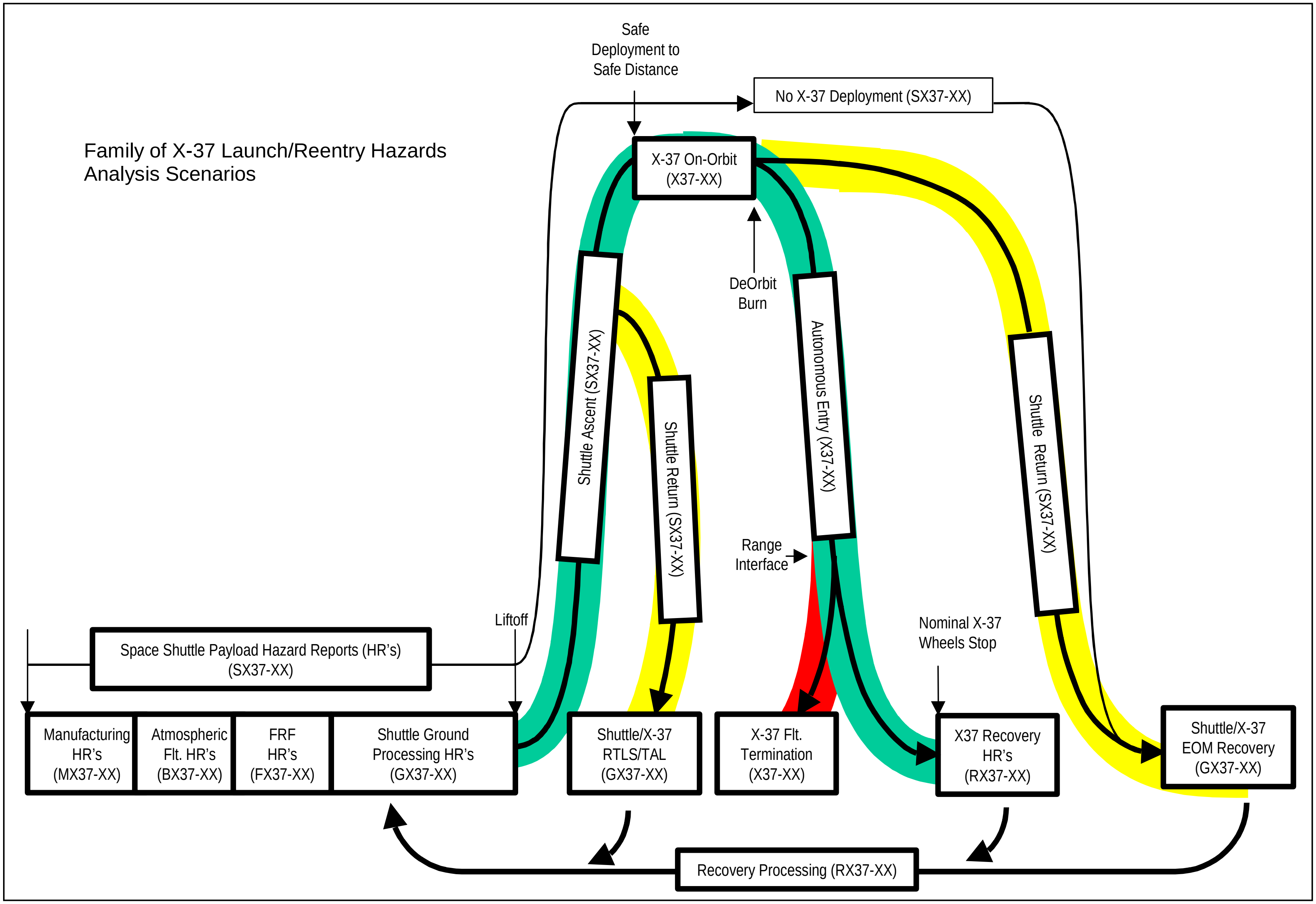


Figure 4.8 Program Hazard Report Scope

Concerning preflight/operations verification, Boeing has proposed a Verification Tracking Database (VTD) process that parallels the process used for payload and ground safety as defined in NSTS/ISS 13830. In this process the signed and baselined X-37 hazard reports are archived in the EVS database. All open items are logged into the VTD process where the test team and system safety team track the closure of these open items based on the appropriate milestone event. These critical milestones are currently defined as:

- X-37 Rollout
- Atmospheric Flight Tests
    - X-37 CoFR
    - Dryden Independent Review Team/Airworthiness Flight Safety Review Board (AFSRB)
    - Taxi Tests
    - Captive Flight
    - Free Flight
- X-37 Flight Readiness Firing (FRF)
- Shuttle Flight Tests
    - KSC Delivery
    - X-37 FRR
    - X-37 ORR
    - Shuttle FRR

VTD closing actions will be verified complete when signed by program management at both Boeing and NASA/MSFC.

Tools

The principal hazard reporting and database tool is the Hazard Entry and Maintenance Program (HEMP) which is a locally developed, Microsoft Access based program. It is proven, accepted, and baselined for usage on the Shuttle program (particularly orbiter and integration hazard reports) and has been modified for application on the X-37 project. Other tools include the Computer Aided Fault Tree Analysis (CAFTA) which is a SAIC developed, commercial off-the-shelf (COTS) product and the Boeing developed Fault Tree Analysis and Builder (FTAB). Standard COTS Microsoft Office 2000 software is also used.

Internal/External Reviews

Internal and external reviews provide control and verification of the system safety processes and the identification and tracking of hazards. The internal Boeing reviews involve the system safety team, vehicle IPT leads and design engineers, and program management. External reviews include:

- MSFC Payload Safety Readiness Review Board (PSRRB)
- JSC Payload Safety Review Panel (PSRP) Phase 0/l, II, III

- KSC Ground Safety Review Panel (GSRP) Phase II, III
- DFRC Flight Test Independent Review Team
- USAF/Range Flight Test AFSRB

An additional independent assessment is provided by the X-37 Program System Safety Working Group (SSWG). This working group has the initial responsibility of reviewing and providing comments to the preliminary hazard report prepared by the system safety lead and the vehicle IPT engineers as indicated in figure 4.9. The SSWG is co-chaired by NASA and Boeing and includes membership from:

- MSFC SMA and Project Office
- JSC SMA
- KSC SMA
- DFRC SMA
- AFFTC Range and Flight Safety
- Vandenberg Air Force Base (VAFB) Range and Flight Safety
- Boeing/Seal Beach System Safety
- Boeing/Huntsville System Safety
- NASA Headquarters SMA

<u>Planned Products</u>

Principal products in work include fault tree analyses addressing the following specific top-level events:

- Inability to deploy the X-37 from the Shuttle payload bay
- Inability of the X-37 vehicle to deorbit
- Inadvertent venting of hydrogen peroxide (oxidizer for the AR2-3 engine) from the X-37 vehicle while captive in the Shuttle payload bay
- X-37 vehicle flies or lands outside planned trajectory or landing site
- X-37 vehicle re-contact with the B-52 aircraft following release

4.2.4 Major Technical Reviews

Technical engineering reviews are scheduled during the life of the X-37 project. The type and frequency of reviews is established according to the unique needs and requirements of the program.

<u>Systems Requirements Review (SRR)</u>

The program had completed the SRR in the mid-1999 time frame. System functional and programmatic requirements were identified which provided the basis for release of the X-37 system specification.

Shuttle Payload Safety Review Panel (PSRP)

Shuttle payload safety reviews are held by the JSC payload safety organization. The purpose of these phased reviews is to assure that the X-37 vehicle satisfies the safety requirements of the Shuttle Safety (NSTS 1700.7B). The phase 0/1 review was completed in (12/00). The remaining reviews to be conducted are the phase 2 (verification) and phase 3 (certification).

Initial Design Review (IDR)

Boeing has completed an IDR in early 2000. The review was conducted for the vehicle and associated ground equipment initial design. The following plans were reviewed: program plan, configuration management plan, risk management plan, program safety plan, quality plan, technology tracking plan, and the flight test plan. An additional IDR (#2) is scheduled for early 2001.

Final Design Review (FDR)

Boeing will conduct a review of the X-37 vehicle and ground equipment final design and updates to the plans baselined at the IDR.

Design Certification Review (DCR)

A DCR will be conducted by MSFC upon execution of the verification plan and IV&V efforts, prior to flight test. The review and participants will provide certification documentation and supporting data that the design satisfies the requirements and that the system performance is satisfactory to achieve mission success. The DCR will be conducted after the FDR, but prior to the FRR. The review will include participation of cognizant management personnel from NASA, USAF, and Boeing, as appropriate.

Flight Readiness Review (FRR)/Certification of Flight Readiness (CoFR)

Prior to each flight test a FRR will be conducted to gain the commitment from all responsible parties, through a CoFR, that the system is ready for the flight test. Additional reviews will be conducted in support of flight readiness:

- Airworthiness Flight Safety Review Board
- Risk Assessment Review for Atmospheric Flights
- Orbital Flight Readiness Review

Other technical reviews may be scheduled as required and as agreed to by the parties.

4.2.5 Reliability

As the X-37 project is currently defined, Boeing has established a reliability program and approach that incorporates most of the elements typically found in a major flight hardware development program. This begins with a numerical reliability requirement as specified by NASA and which has been translated into design specifications which will in turn meet the probability of mission success (POMS) and fault tolerance requirements. This overall approach ensures the earliest participation in design reviews and critical trade studies and requires reliability analysis and modeling which accepts and can incorporate both estimates and test data.

Specifically, reliability data will be used to determine:

- POMS
- Probability of meeting expected casualty rate (Ec) and property loss due to over-flight and landing accidents
- If, and when, alternative landing sites need to be considered
- Scope of prelaunch checkout activities required to maximize the POMS
- Degree of fault tolerance compliance

The reliability process encompasses knowing what could fail, how it could fail, what the consequences are, how often failures will occur, and when failures are likely to occur. This process will also account for the likely condition of each line replacement unit (LRU) for each hour of the mission including reentry and landing. The principal tools to accomplish these "what's" are the development of key failure modes effects and critically analyses (FMECA) and the application of the MAtrix reliability and the SIMtrix simulation models.

Currently, a first draft FMECA is available for the following areas:

- Power distribution and control
- Flight termination system
- Flight management system
- GPS system
- Attitude control
- Ku band
- Radar altimeter
- Airframe structure
- Thermal control
- Brakes
- Pressurization
- Fuel system
- Main engine
- RCS
- Actuators
- Landing gear
- Power generation
- S-band
- Avionics

The Excel-based matrix model generates "standard" USAF reliability/maintainability/availability parameters (i.e., MTBM, MTBR, MTBF, etc.) and loss of vehicle (LOV) and loss of mission (LOM) calculations. It encompasses major operating environments (launch, on-orbit, and reentry) and aircraft type. Each component and LRU is modeled, each having a unique duty cycle and, where applicable, quiescent time. Redundancy, fault tolerance, and mission criticality is applied where appropriate from embedded reliability block diagrams. The model is also designed for easy replacement of preliminary reliability and maintainability estimates with vendor-supplied data when available. The model provides POMS and vehicle loss rates over an entire mission, or by mission segment, e.g., during approach and landing.

The SIMtrix model, which provides a Monte Carlo simulation of the X-37's major subsystems and components, has been completed and is currently operational. The model steps through the X-37 mission in 1 hour time increments. At each time increment the failed or non-failed status of each component is determined based upon previously supplied component failure rates. The Monte Carlo nature of the simulation requires that each mission be repeated often enough so that valid output statistics can be obtained. Typically, each mission is "flown" a minimum of 25,000 times. Output tables depict for each component if and when failure occurred (in terms of how many of the 25,000 simulated missions had failures and at what time of the mission each failure occurred). The potential consequence of each failure is used, if necessary, to redirect the course of the mission.

4.3 Quality Assurance (QA) Processes

The mission of Boeing's Program Quality Office at Seal Beach is to ensure high quality standards are met while keeping within the X-37 project's rapid prototype structure. This is to be accomplished through the uniform application of QA requirements consistent with established Boeing Company policies, procedures, and standards. The overall objective is to ensure effective quality processes are in place and implemented, resulting in:

- Conforming parts and assemblies
- Conforming assembly, integration, and test
- Authorized disposition for nonconformance resolution
- Acceptance records and traceability data required for vehicle certification

The overall approach for implementing quality assurance on the X-37 project centers on the cooperative agreement philosophy that reflects an "insight" role by NASA rather than the traditional or conventional "oversight" role. Thus, there is no prescriptive flow down of NASA stipulated quality requirements. However, the cooperative agreement statement of work does require the development and implementation of a quality assurance plan. The development of the X-37 quality assurance plan conforms to the ISO compliant Boeing Quality Management System (BQMS) and stipulates that the various interdivisional work authority (IWA) sites are to use their site-specific BQMS procedures unless the content of the top-level plan dictates unique project specific procedures and processes. To this end, the IWA sites will create additional quality plans if additional site specificity is required.

Figure 4.9 depicts the quality requirements flow down from the cooperative agreement to the BQMS, the program quality office, the IWA sites, and external suppliers

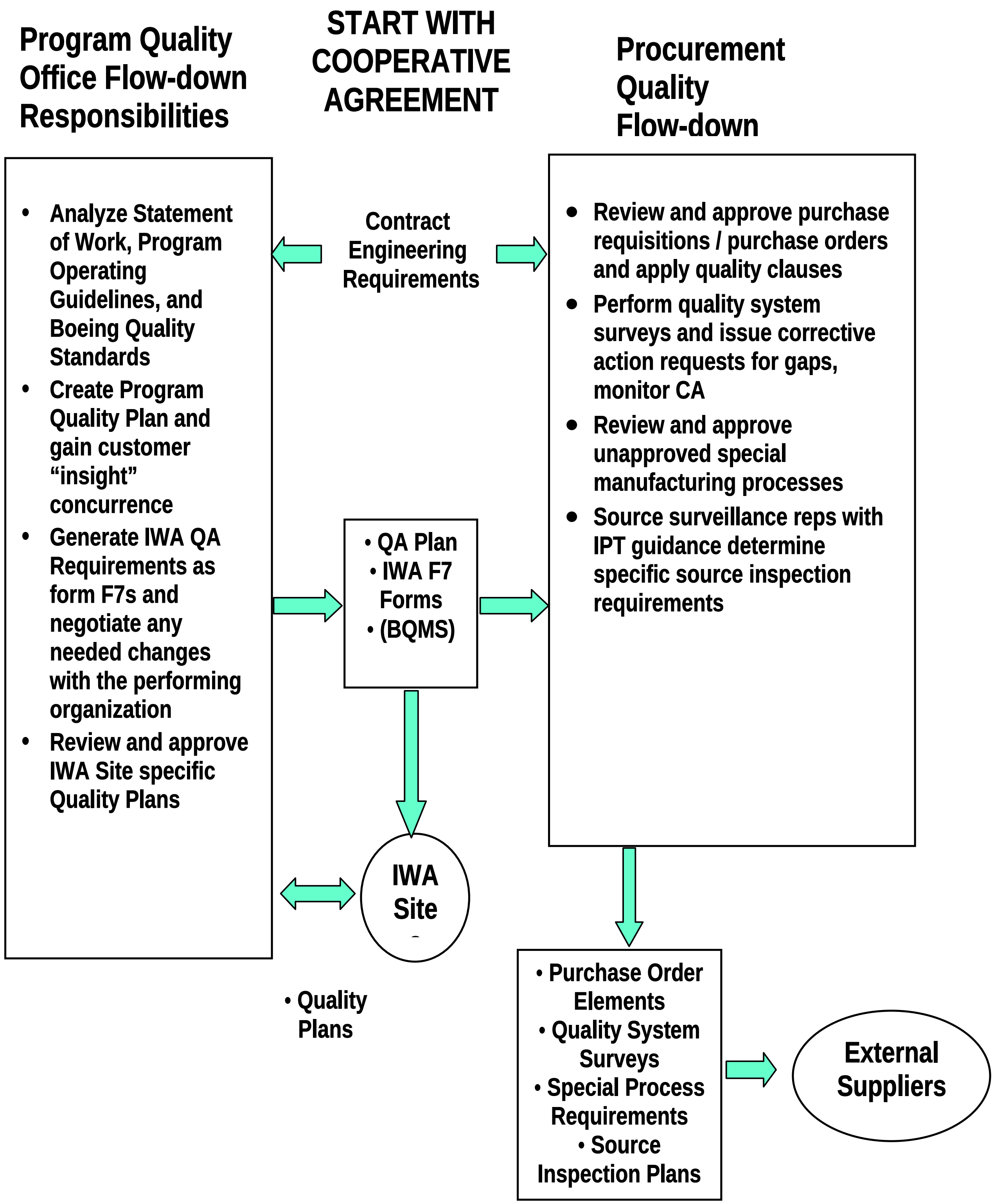


Figure 4.9 Flow of Quality Assurance Requirements

To assure the satisfactory completion of the above activities, a combined quality assurance team will be formed. The team will be composed of representatives from:

- Program Quality Office - Seal Beach
- Procurement QA - Huntington Beach
- Software QA - Huntington Beach
- Manufacturing QA - Multiple IWA sites
- Assembly, Integration, and Test QA - Palmdale

The primary function of this team is to provide for the appropriate QA requirement flow down both internally (to IWA sites) and to external suppliers by way of the purchase order system. The team will also provide QA oversight and guidance across Boeing X-37 participants and assure that basic process controls, validation and acceptance practices, and data packages meet required QA standards.

In general, the program quality office provides support in the following functional areas:

- Establish quality requirements
    - create quality assurance plan
    - review A and B level specifications
    - create IWA quality requirements
- Provide IWA support
    - assure flow down of quality requirements
    - review IWA site-specific quality plans
    - provide ISO audit support
- Provide program management support
    - attend biweekly program manager's meeting
    - address QA issues for IPT leads and PM
- Analyze digital mock-up (DMU)
    - assure supplier ability to maintain configuration management and produce conforming hardware and software
- Serve as customer QA interface
    - notify NASA of major QA issues
    - provide software QA support
    - monitor and support SQA problem reporting/resolution
- Conduct supplier quality surveys
    - establish quality system/ISO 9001 status
    - monitor supplier corrective action requests resulting from surveys
- Provide backup for Procurement QA
- Conduct supplier oversight
- Provide oversight of preparations for verification/certification of atmospheric and orbital testing

Project specific support in these functional areas will be provided to the X-37 project as appropriate.